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OCT 27 1943

BORDEN'S REVIEW of NUTRITION RESEARCH

Summaries and reviews of research information concerning the nutritive values of milk and milk products. Published by The Borden Company, 350 Madison Avenue, New York 17, N. Y.

OCTOBER, 1943 VOL. IV, No. 7

THE CONQUEST OF PELLAGRA

During the middle of the last century, the age-old fight against human disease and suffering attained its most spectacular victories when Pasteur, Koch, Lister and others demonstrated the importance of microbes as causative factors in disease. Recognition of the basic causes of such diseases as scarlet fever, bubonic plague, yellow fever, and numerous others, provided the weapon which eventually made possible the control and elimination of these scourges. The discovery of the germ theory of disease and infection will always remain one of the most significant of human achievements.

Because of its fundamental importance, the germ theory of disease dominated the thinking of medical science for many years. Shortly after the beginning of the present century, the discovery of the vitamins introduced an entirely new concept in the origin of disease. This radically different concept was the more difficult to accept because it postulated certain diseases arising, not as a result of positive causative factors such as infectious micro-organisms, but as a result of the *absence* or *insufficiency* of specific factors in food recognized as being vital to body health and functioning.

One of the most dramatic examples of how difficult it was to accept the revolutionary concept of a *deficiency disease* is revealed in the story of pellagra, a disease which destroyed many lives and perplexed medical scientists for almost two centuries before the cause and cure were recognized. Pellagra, as well as other deficiency diseases, is a disease of deprivation resulting from a form of starvation. So strikingly akin, however, are its manifestations to the symptoms of virulent infection, that many decades were spent in an attempt to find a germ or toxin which could be held responsible for pellagra, before the realization came that a lack of vital food factors is the cause.

Today, almost thirty years after the recognition of pellagra as a dietary deficiency disease, the incidence of pellagra is still inexcusably high, even in abundant food producing countries such as the United States. Pellagra exists in endemic form in various sections throughout the United States and it has been indicated that even in non-endemic areas, there are many cases of sporadic and subclinical pellagra which all too frequently escape detection. Recently reported statistics reveal that from three to four thousand deaths occurred annu-

ally as a result of pellagra in the period from 1933 to 1938. It is estimated, further, that thousands of deaths ascribed to "alcoholism," "alcoholic encephalopathy," and other generalized causes, actually have been due to pellagra or specific nicotinic acid deficiency. On this basis, it has been estimated that there were more than 100,000 cases of active pellagra in the United States in 1938. Even in the last few years many cases of severe disability, insanity or death have resulted from pellagra, a disease caused by nothing more sinister than an inadequate diet.

People who eat a well-balanced diet of fresh meat, milk, eggs, fruit, vegetables and cereals do not suffer from pellagra. The achievement of such an adequate diet is influenced by many problems involving economic factors, food fads and prejudices, ingrained faulty food habits and ignorance. More widespread education in the principles of nutrition is one of the most important preventive weapons against pellagra. Because pellagra in the United States still remains a significant public health problem today, many nutrition authorities suggest enrichment of staple foods such as flour, bread and refined cereals with required vitamins and minerals as a practical immediate expedient.

The Nature of Pellagra

Pellagra is a complex degenerative disease now known to be induced by nutritional deficiency. It is characterized by various types of skin lesions, certain of which are precipitated and aggravated by exposure to sunlight. These lesions present a strikingly symmetrical distribution over the body, so that lesions on the right side of the body appear in corresponding areas on the left side as well, and are usually similar in extent and in peculiarities of outline. In addition to the characteristic dermatitis, pellagra is manifested in lesions of the mucous membranes, disturbances of the digestive tract, muscle weakness and impairment of the nervous system which frequently ends in insanity. It has been described as one of the most formidable and deadly of human diseases. One of the most vivid descriptions of pellagra appears in the following excerpt from an early Italian treatise (1) on the subject:

"If you should traverse the hills of Brianza and Canavese, you would most likely meet some pitiable wrecks of humanity, with eyes fixed and glassy, with pale and sallow faces and arms fissured and scarred as by a burn or large wound. You would see them advancing with trembling head and staggering gait like persons intoxicated or indeed, as though impelled by an invisible force, now falling on one side, now getting up and running in a straight line like a dog after its quarry and now again falling and uttering a senseless laugh or sob which pierces the heart—such are the pellagrins. . . ."

Historical Background

The earliest known recognition of pellagra was in 1735 when Don Gaspar Casal, physician to Philip V of Spain, described a hitherto unknown disease

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particularly prevalent among the poor peasantry. Three years after his death, Casal's description of the disease was published, setting forth in detail the classic symptoms of pellagra as it is known today and suggesting the probable significance of a poor diet as a causative factor (1a).

In 1771, beginning with the studies of Frapolli, who first named the disease pellagra (from the Italian, *pelle,* skin, and *agra,* rough) (2), the widespread occurrence of pellagra in Italy was recognized and for more than one hundred years, scores of Italian physicians devoted years to the study of the strange malady. Many decades were spent trying to find the mysterious cause of pellagra and many elaborate theories were evolved purporting to solve the mystery. The theories concerning the origin of pellagra grew in number as the disease progressed from Spain and Italy to France, Austria, Hungary, Rumania, the Balkans, and Egypt. Yet, in 1914 the solution of the problem was no nearer than it had been in the days of Casal.

Pellagra was yearly becoming more widespread. Since the early studies in Italy, it had come to be dreaded as a "terrible affliction . . . hurrying whole populations to the grave" (3). Yet, not knowing the cause, there was little which could be done in its prevention. Out of the morass of theories, two were outstanding: pellagra was thought to be caused by (1) a toxic substance present in corn, a cereal forming a considerable portion of the diet in regions where pellagra was prevalent, and (2) by infection with a specific living microorganism. These early theories persisted and occupied the greater part of research devoted to pellagra for many decades. With research directed, as it was, along these lines of fallacious reasoning, the solution of the problem of pellagra became more confused and hopeless than ever.

Early in the twentieth century, pellagra was recognized in the United States. Between 1905 and 1910, following reports by Searcy, Babcock and several other investigators, awareness of the existence of the disease throughout the country grew. Pellagra was reported in at least twenty-six states. In six of these states alone, South Carolina, North Carolina, Mississippi, Alabama, Tennessee, and Texas, where the disease was most prevalent, the mortality of pellagra was more than four thousand people yearly.

Because of the sudden and violent onset of the disease, its epidemic proportions, and its frequent fatal termination, the theory of pellagra as an infectious disease still dominated the minds of investigators. In 1910 the Illinois Pellagra Commission, and in 1912 the Thompson-McFadden Commission were organized to set about investigating the alarming increase of pellagra, especially in state hospitals. These two groups, consisting of trained medical men, succeeded in disproving many of the erroneous theories evolved during the past two centuries, but unfortunately, concluded that pellagra was caused by infection with an unkown microorganism.

In 1914 the pellagra situation in the South had become critical. The United States Public Health Service had already spent five years studying the problem from all conceivable points of view, but the search for the cause of pellagra remained fruitless. In a final attempt to unravel the mystery of the tragic disease, the problem was assigned to Dr. Joseph Goldberger, Surgeon in the United States Public Health Service, because of his brilliant record in combating typhoid, yellow fever, diphtheria and other diseases.

Goldberger's Experiments— Solution of the Pellagra Problem

The year 1914 marked the turning point in the long, confused history of pellagra. Discarding the tremendous mass of literature and conflicting theories which had accummulated through the years, Goldberger set out to study the problem of pellagra from the vantage point of first-hand observations. After an intensive preliminary study of prevailing conditions in the South where pellagra was annually taking a large toll of human lives, he was particularly impressed by three significant facts. First of all, he pointed out (4) pellagra was a disease invariably associated with poverty; secondly, it was more prevalent among rural people than among city dwellers; and last, but most impressive, in hospitals where hundreds of inmates were stricken with the disease, *not one of the doctors, nurses or other hospital employees had ever contracted the illness!* This last observation seemed to indicate very strongly, contrary to popular and medical opinion at the time, that pellagra was not an infectious disease.

From these initial clues, Goldberger built up his theory concerning the probable cause and true nature of pellagra. He reasoned that since hospital employees living in intimate contact with pellagrous inmates, never developed pellagra, there must be a logical explanation for their immunity. After careful analysis of the environmental conditions of both groups, he came to the conclusion that the only difference in the conditions between the patients and the hospital staff was their respective diets. To all outward appearances, the diet of both groups was much the same. Upon closer inspection, however, it became apparent that the hospital staff had access to more food, had first choice as to available foods and could select their meals from a wider variety of foods than could the patients. Furthermore, because of their illness, patients frequently did not eat all the food provided, or refused many foods. Hospital employees also were in a position to supplement the hospital dietary with foods from outside sources. These observations also tied in with the fact that pellagra was associated with the poor who could not afford a large and varied diet. This was especially true in rural areas where the land was devoted almost exclusively to the cultivation of cotton or tobacco instead of to the pro-

duction of food crops. In the cities, the people, even though poor, had a wider variety of foods from which to choose. All these facts left very little doubt that a limited diet, not infection, was the cause of pellagra.

Having reached this conclusion, Goldberger set about studying pellagra exclusively from the dietary point of view. The question of prime importance was: What factor in the diet is responsible for the development of pellagra? This was indeed a puzzling problem. Goldberger suggested that since most pellagrins ate chiefly cereals, vegetables and canned foods, the disease might be prevented by improving the nature of the diet. He recommended, therefore, an increase in the "fresh animal food component" as represented by fresh meat, eggs and milk.

Prevention of Pellagra by Diet: Before proceeding further with the dietary investigation of pellagra, Goldberger felt that more concrete evidence was required in support of his theory. First of all, therefore, he set about to disprove the infection theory supported by the Illinois Pellagra Commission and the Thompson-McFadden Commission. For this purpose, one hundred monkeys were inoculated with skin scales, secretions and excretions from persons severely ill with pellagra. None of the animals so inoculated developed the disease. This experiment was followed by careful statistical studies on the incidence of pellagra in hospitals. It was found that at the Georgia State Sanitarium, 7½ percent of the inmates developed pellagra within one year after admission, whereas the incidence of the disease among the attendants was zero. Even stranger results were reported at an orphanage in Mississippi. Thirty-two percent of the children had pellagra, but the disease appeared to afflict only certain age groups. Most of the cases occurred among children from six to twelve years of age, the children under six being relatively immune, as were also the children over twelve. Environmental conditions were the same for all the children, but here again, dietary differences were apparent. The youngest children received milk in addition to the regular diet; the middle group receieved only the regular diet; the "big boys" in the oldest group were allowed meat occasionally and, because they were bolder than the younger children, supplemented their meager diet with extra stolen rations to appease their hunger. Consequently, the children in the middle group were the ones who exhibited the most signs of dietary insufficiency. All these facts were cited in a letter to the United States Surgeon General (5) as incontrovertible evidence that somewhere in the diet would be found the true explanation for the cause of pellagra.

The time had now come to put the theory to the test. Previous observations had indicated that attacks of pellagra recurred regularly among inmates of various institutions, and that the extent of such recurrences was more or less predictable. Accordingly, Goldberger and his associates attempted to check the recurrence of the disease by feeding selected groups of people the scientifically recommended diet containing a greater proportion of fresh meat, eggs and milk. The test was conducted in two orphanages and in one hospital. The results of their tests were more illuminating than they dared expect. Out of 67 children at one of the orphanages, most of whom had already had two annual attacks of

pellagra, there were no recurrences. At the second orphanage, only one child out of 105 had a recurrence of pellagra. At the hospital, none of 72 patients on the superior diet had a recurrence of pellagra, while among the remainder of the patients in the hospital, subsisting on the regular hospital diet and thus acting as a control group, there was a 47 percent recurrence of the disease. Goldberger, and his associates, Waring and Willets, were at last able to announce that the first step forward in the solution of the pellagra problem had been made —*pellagra had been prevented by diet* (6).

Production of Pellagra by Diet: Dramatic as it was, the prevention of apparently inevitable recurrences of pellagra by diet alone, represented merely a preliminary step. It indicated, however, that at last the investigation of pellagra was on the right track. The real test of the importance of diet in pellagra would be the production of the disease in normal, healthy persons by feeding them a diet similar to that upon which the majority of pellagra sufferers in the South subsisted. Such a test was finally proposed, resulting in the now-historic prison farm experiment.

For this experiment a group of twelve volunteers was selected from convicts at a prison farm in Mississippi. These men agreed to serve as human guinea pigs for a period of six months during which they were to eat only the so-called pellagra-producing diet devised by Goldberger and his collaborators. The diet consisted of foods commonly eaten by the poorer classes in the South—biscuits, fried mush, corn grits and brown gravy, syrup, black coffee, sugar, corn bread, cabbage, sweet potatoes, rice and collards. Except for this restricted diet, the men were to continue in their normal routine, confined on the farm in clean, screened quarters. A large group of fellow prisoners living under identical conditions, except for diet, were to be kept under surveillance as controls. As a reward for their cooperation, the small group of volunteers was promised freedom at the close of the experiment.

Prior to the experimental period, the men were kept on a normal, well-balanced diet for two months during which time they were observed and found to be in good health. None had ever had a history of pellagra. After the preliminary observation period, the special diet was put into effect. Day in and day out the volunteers ate nothing but the twelve food items listed above for breakfast, dinner and supper. After a few weeks on this diet, the convicts began to feel queer. They developed headaches, stomach-aches, backaches, dizziness. They became listless and were easily fatigued. But there were no outward signs of pellagra. Four months passed. The men grew mutinous on the tiresome diet. The thought of freedom at the end of two more months served to keep them going, although they were growing weaker daily and could no longer work. Still there was no sign of the characteristic rash on any of them. Goldberger and his assistants were worried. The restricted diet was having a marked effect upon the men, yet without the appearance of characteristic skin lesions, a diagnosis of pellagra

could not be made. Suddenly, with little more than one month to go, one of the men developed a rash. Twelve days later, six men out of a total of eleven (one volunteer had dropped out because of another illness) presented the same skin lesions. There no longer could be any doubt. The men were suffering from pellagra. The control group was still perfectly healthy. It was apparent to all concerned that the only possible cause of pellagra in the volunteer group was the special, restricted diet to which they had been subjected.

Non-Transmissibility of Pellagra: Despite the dramatic results of Goldberger's prison farm experiment, there were many authorities who were not yet convinced. They persisted in their claims that pellagra was an infectious disease, maintaining that man was the only creature susceptible to the disease thereby explaining the failure of many workers to transmit the disease to monkeys and other experimental animals.

There was only one way to overcome this last stronghold of the infection theory and that was to attempt to transmit pellagra to human subjects. Goldberger, his wife, friends and co-workers, including Wheeler, Willets, Sydenstricker, Tanner, McCoy and others—all of whom remained anonymous in the report of the experiment (8) —served as the volunteers in this experiment. This experiment, as well as a number of others which followed, was one of the most gruesome of all those undertaken by the tireless workers in the Public Health Service. The volunteers were injected with blood from pellagrous patients, their noses and throats were carefully swabbed with secretions collected from these patients, and finally, they were given pellets to swallow containing a mixture of various excretory products and scales also collected from pellagrins. No possible route of infection was overlooked. Days and weeks passed, but not one of the sixteen volunteers developed any symptoms of pellagra. The reward of these courageous people was the satisfaction of knowing that they had proved to the world, beyond any doubt, that pellagra is not a contagious disease. The mystery thus was solved at last: pellagra, a scourge of two centuries, was a disease caused by faulty diet—a horrible disease which could be wiped out by providing the right kind of food. Toward this goal, Goldberger recommended the keeping of dairy cows and chickens, the planting of gardens, and an increase in markets to provide a wider variety of available foods to the poor. The fight against pellagra had begun.

Search for the Pellagra-Preventive Factor

Now that pellagra had been revealed as a disease of dietary origin, the problem remaining consisted of discovering what foods or what food factors were active in preventing the disease. This aspect of pellagra research was given tremendous impetus by the work of Chittenden and Underhill (9) who reported that they had been able to induce experimentally a pellagra-like disease in dogs by means of an inadequate diet. Goldberger, Wheeler and Blackstock (10)

pointed out, from their study of the available literature, that the experimental pellagra-like disease produced by Chittenden and Underhill, was probably identical to a disease in dogs long recognized by veterinarians and described as "blacktongue." Therefore, they pointed out further, blacktongue in dogs was actually analogous to pellagra in man. The final identification of blacktongue as canine pellagra some years later (13) meant that at last an experimental animal was available for the study of pellagra.

With the availability of the dog as an experimental animal, research proceeded at a rapid pace. It was now possible to test individual foods for their ability to prevent or cure blacktongue induced by the same diet as had been used to induce pellagra in man. It was found that foods which cured blacktongue also cured pellagra in humans. In a preliminary paper, Goldberger and Tanner (11) announced that fresh meat and milk prevented pellagra and also cured it; that gelatin was ineffective as a curative factor, and that butter and cod liver oil were unable to prevent the disease. In 1926, soon after the beginning of their animal studies, Goldberger, Wheeler and Lillie (12) postulated the existence of a new dietary factor which they termed the "pellagra-preventive (P-P) factor." During their early studies on the probable nature of this factor, they had suspected that it might be associated with the protein component of the diet inasmuch as the protein-rich foods were particularly valuable in the prevention of pellagra. However, this possibility was soon eliminated and the conclusion was reached from an analysis of its occurrence, that the unknown factor was probably related to the then newly-recognized "water-soluble vitamin B." Pursuing this line of investigation, Goldberger, Wheeler and Lillie soon demonstrated that the mysterious P-P factor was indeed associated with "vitamin B" (a vitamin then regarded as a single entity and later recognized as a complex of discrete vitamin factors), and that moreover, the pellagra-preventing activity of "vitamin B" was localized in that fraction of the vitamin concentrate which was not destroyed by heat. This meant that "vitamin B" now contained at least two factors: the heat-labile anti-beri-beri factor and a heat-stable pellagra-preventive factor. By 1928, Goldberger and his associates (14) had tested a wide variety of foods for the presence of the pellagra-preventive factor and were close on the trail of the unknown vitamin.

Whether Goldberger would have eventually succeeded in identifying the unknown food factor involved in the prevention of pellagra remains an unanswered question, for he was suddenly stricken with an illness which resulted in his untimely death in January, 1929.

The Discovery of Nicotinic Acid

After the death of Joseph Goldberger, his brilliant work continued to inspire other scientists in the nutritional field. The problem of pellagra was now

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beyond the scope of public health work; it was a question to be answered by the chemists and nutritionists.

At the University of Wisconsin, a group of chemists, Elvehjem, Madden, Strong and Woolley were hard at work on the problem. By 1937 they had progressed to the stage where the search for the pellagra-preventive factor was narrowed down to highly potent concentrates obtained from liver extracts possessing marked pellagra preventing properties. If the active principle in these concentrates could be isolated in crystalline form and identified, the solution of the problem would be found. While engaged in the task of isolating the active principle from these liver extracts, it occurred to these workers to try out the effect of a well-known chemical which had been reported to stimulate growth in experimental rats and which, further, seemed to possess physical and chemical properties very closely related to those of the concentrates with which they were working. This chemical was nicotinic acid.

History and Chemistry of Nicotinic Acid: Nicotinic acid had long been known to chemists, having first been prepared in pure chemical form as far back as 1867. It is called nicotinic acid because it can easily be prepared by oxidizing nicotine, a reaction which destroys the toxic effect of this alkaloid, yielding nicotinic acid. Early in the history of the vitamins in 1911 Funk had isolated nicotinic acid from rice polishings in his search for vitamin B_1, the anti-beri-beri factor. When he found that nicotinic acid did not cure beri-beri, he discarded it and continued the search. Thus nicotinic acid, unknowingly the first vitamin to be isolated, was not recognized as a vitamin until almost twenty-six years later. In the intervening years, this chemical had been recognized as a constituent of certain enzyme systems within the body, and it had been found important for the growth of various types of micro-organisms.

Nicotinic Acid as the Pellagra-Preventive Factor: These Wisconsin investigators decided to try nicotinic acid on dogs suffering from blacktongue. Immediately following a single dose of the material they obtained a dramatic response in one of the dogs. The animal's appetite returned to normal, growth was resumed at the same rate as had been induced by the liver extract, and most other symptoms disappeared. The cure of the other dogs followed rapidly (15).

Simultaneously with the discovery of the curative properties of nicotinic acid in canine blacktongue, Elvehjem and his co-workers succeeded in isolating nicotinic acid amide from their potent concentrates and demonstrated that the amide was equally as effective as the acid form of this compound.

In their report of this exciting discovery, they concluded:

"These and other results demonstrate the close relationship of nicotinic acid and nicotinic acid amide to blacktongue. The fact that nicotinic acid amide is an essential ingredient of the diet is not surprising since it is a component of certain coenzymes. However, the observation that a deficiency of this material may be the cause of blacktongue is most interesting. Whether these compounds are equally effective in human pellagra can only be answered by clinical trials."

With these historic words, the final solution of the mystery of pellagra was imminent—exactly two hundred and two years after this terrible affliction had

first been recognized by Casal. The importance of nicotinic acid (niacin) as a key vitamin in the treatment of human pellagra was soon confirmed by clinical studies, thereby adding a new and intensely interesting chapter to the story of modern nutrition.

The story of pellagra and its treatment with nicotinic acid as well as other B vitamins, will be continued in the November, 1943 issue of BORDEN'S REVIEW *of* NUTRITION RESEARCH.

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NEWS DIGEST

COTTONSEED, SOYBEAN AND PEANUT MEALS, produced by expressing the oil from the respective seeds, can be important sources of edible protein and B vitamins in the dietary. Investigation of these products now used in animal feeding shows that they are all analagous in general nutritive quality. Soybean meal, however, has been found to be outstanding in the quality of its protein, whereas cottonseed meal excels in riboflavin content, and peanut meal is richest in nicotinic acid. As substitutes for both the protein and the vitamins of meat, a mixture of the three seed meals offers possibilities in the human diet.

—1001

MUSHROOMS, at present scarce in fresh form, can now be obtained in the dehydrated state. The dried mushrooms are available in waxed glassine envelopes and are readily reconstituted with water. Preparation of the product involves a preliminary soaking in boiling water for half an hour, after which the mushrooms can be used in soups, sauces, and omelets, or with spaghetti, steak, chicken livers, and the like, in the same fashion as the fresh product.

—1002

VITAMIN RETENTION IN COMMERCIALLY DEHYDRATED VEGETABLES is the subject of current studies on the nutritive value of these products as affected by processing and storage. Results have already been reported for four vegetables: rutabagas, beets, cabbage and potatoes. None of these vegetables lost any significant amount of carotene during dehydration, but losses of this vitamin were fairly rapid at all storage temperatures above 40° F. All of the vegetables lost small amounts of thiamin during preliminary blanching, but exhibited no further losses on storage. The vitamin C loss was most marked, practically all of the vegetables losing considerable amounts during the processing. Potatoes lost most of their vitamin C content, beets (initially low in vitamin C) lost one-third of their original vitamin C content, and rutabagas lost approximately 85 percent of their vitamin C. Cabbage, on the other hand, retained its vitamin C content better than the other three vegetables, both during dehydration and storage. The finished product was high in vitamin C, containing more than 3 milligrams of vitamin C per gram of dehydrated cabbage.

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BETTER FOOD DEHYDRATION through the use of radio-frequency energy has recently been developed. After a preliminary dehydration of vegetables by present methods, resulting in removal of 80 percent of the water, the vegetables are compressed into blocks from which the remaining moisture is reduced to one percent by radio-frequency energy in a partial vacuum. Foods dehydrated by ordinary means usually retain at least 5 percent moisture, an amount which is sufficient to render them easily subject to spoilage, especially in the tropics. The new electronic method makes possible for the first time removal of 99 percent of the moisture, and has the advantages of permitting more uniform, quicker and cheaper processing. It is indicated that vegetables dehydrated by the new electronic method will not deteriorate over a period of from one to two years, even in hot, humid climates. Furthermore, because of the rapidity of dehydration, the vitamin retention in products dried by this method, is unusually high. Plans are now being made to test the radio-frequency dehydration method on a commercial scale with an electronic drier equipped to handle six tons of dried food a day, an amount roughly equivalent to about 60 tons of fresh food.

—1004

CALCIUM has been demonstrated to be an important factor in reproduction of experimental animals. Tests conducted to determine the effects of calcium deficiency on the reproductive powers of young and mature rats showed that young animals, reared from weaning time, on a low-calcium diet failed to mate upon reaching maturity. Mature animals which had previously given birth to young, exhibited a marked decrease in fertility upon transfer to a special low-calcium diet. The number of viable young produced by these mature animals was very low. Calcium deficient mothers and young exhibited marked symptoms of susceptibility to hemorrhage, prostration and paralysis induced by galvanic shock. The symptoms were especially severe in the young. Calcium deprivation proved more of a drain upon the calcium stores of the mother during lactation than during pregnancy. The calcium deficient mothers were unable to provide enough milk to allow for normal growth of the young.

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SWEET POTATOES may soon be used to produce new types of prepared ready-to-eat food products. Reports from a Southern Agricultural Station indicate that from twenty to thirty new products, ranging from breakfast foods to various types of confections, have already been prepared. The new process combining cooking, extruding and finish drying, yields finished foods of 2½ to 4 percent moisture which are ready to serve without cooking. The prepared sweet potato products contain fairly large quantities of carotene and vitamin C and about 80 percent of carbohydrate over half of which is sugar. Production of these new foods on a small scale in preparation for later large-scale operations is expected to begin shortly.

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